

POSSIBLE EXPERIMENTS ON THE 200-GeV ACCELERATOR

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We will describe a number of experiments that might be done on the 200-GeV accelerator. We have tried to emphasize experiments which might give unexpected results at high energy. However, we have probably emphasized the experiments that we are most interested in.

A large fraction of the experiments in high energy physics in the last ten years have been concerned with the problem of particle spectra. It cannot be assumed that this will be true for the 200-BeV accelerator (or even continue to be true for present accelerators). One may be forced, even unwillingly, to more difficult problems, which have not yet been faced. The investigation of jets, i. e., of highly multiple processes, may become an important element of the research program. Cosmic-ray experiments have given some information on the most common type of jets. Questions may arise as to the frequency of occurrence of more violent events, with large transverse momentum transfers, which give evidence of the occurrence of interactions at very small distances. We mention such possibilities to remind the reader that the future will be different from the past.

TOTAL CROSS SECTIONS

These can be measured for p , \bar{p} , π^+ , π^- , K^+ on hydrogen. The rates

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are good. Present techniques should work well. Only new problem is that diffraction peak is narrower $\left[d\sigma/dt \propto e^{-p^2\theta^2} \right]$ so that good geometry correction will be a little harder. These should be interesting and valuable experiments.

SMALL ANGLE SCATTERING AND REAL PART OF SCATTERING AMPLITUDE

The shrinkage is likely to be small above 30 GeV and difficult to study precisely. To study real part will need better angular resolution to see interference with Coulomb scattering $[\theta_{\text{inter}} \sim 1/p.]$ The real part will grow smaller because of the many channels opening up and it will be difficult to get small enough errors to see how fast it decreases. Thus these experiments are unlikely to yield exciting results, nevertheless they should be done to insure that the cross sections do behave as expected. Present techniques will probably be adequate.

SEARCH FOR UNKNOWN PARTICLES

There will be $W = 19.4$ GeV of total energy. Thus, production of pairs of particles is possible with masses up to ~ 8.8 GeV. One will look for Quarks, W's and Monopoles at least. Techniques will probably be:

Conventional time of flight

Time of flight relative to a single RF bunch which might be
extracted

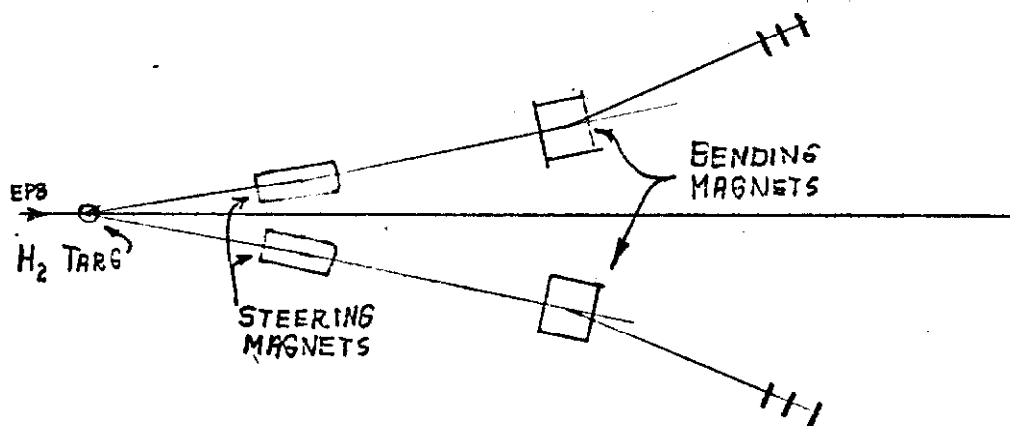
Cherenkov counters (differential and threshold)

Relativistic rise counters

Calorimeter

LARGE ANGLE PROTON PROTON ELASTIC SCATTERING

If the experiment is done with the protons from the EPB as target protons and a one-foot H_2 target $d\sigma/d\Omega$ cm down to 10^{-38} cm^2/sr can be measured. If the cross section continues to drop without breaking, we should be able to go out to about $P_{\perp}^2 \approx 15(GeV/c)^2$. The experiment would probably be done with two spectrometers looking at each proton from 500 \rightarrow 1000 ft long. There would be bending magnets for momentum analysis and steering magnets close to the liquid H_2 target to compensate for the change in lab angle as θ_{cm} is changed.



A few 2 meter magnets will give enough bending but superconducting magnets would be nice. It might be best to first do the experiment at 100 GeV because it might be hard to handle the high energy particles coming from a 200 GeV collision. It will be necessary to have the following provisions in the design of the 200 GeV accelerator.

- a) Target station with room for nearby steering magnets in EPB.
- b) Room for beams of about 500-1000 ft.

Typical experiments:

Hold θ_{cm} fixed and vary P_{inc} .

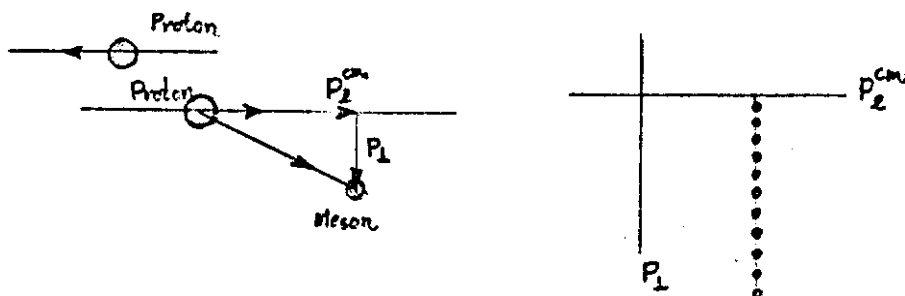
Hold P_{\perp}^2 fixed and vary P_{inc} .

Hold P_{inc} fixed and vary θ_{cm} .

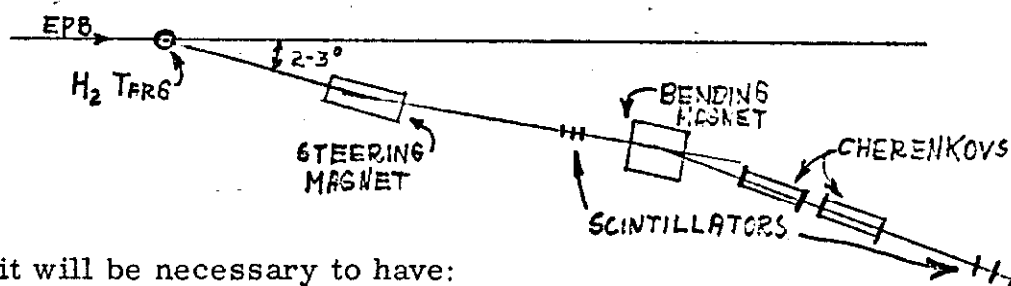
It will be interesting to see if there are any further breaks in the p-p cross section.

MESON PRODUCTION IN P-P COLLISIONS $P+P \rightarrow \text{MESON} + \text{ANYTHING}$

Study the differential production cross section $d^2\sigma/d\Omega dp$ for the production of $\pi^{\pm} K^{\pm}$ and perhaps \bar{p} 's in 200 GeV/c proton proton collisions. It will probably be best to make this study in the center of mass or in the rest frame of the "fireball" after it is well located. The produced particles can be detected with a single arm spectrometer (~ 1000 ft. long) and tagged by long threshold Cherenkov counters. There will probably be a steering magnet to compensate for charges in θ_{lab} due to changes in P_{\perp}^2 and P_z^{cm} and a bending magnet for momentum analysis. With $\Delta\Omega\Delta p \sim 10^{-5}$ GeV/c sr cross sections out to $p_{\perp}^2 \sim 4-6$ (GeV/c) 2 can probably be studied.



If one observes particles with $p_{lab} \approx 40$ GeV we have for $\gamma = 1/\beta$
 $\pi \approx 5 \times 10^{-6}$ $K \approx 10^{-4}$ $P \approx 3 \times 10^{-4}$ and one can probably tag things with
 threshold C counters. If one goes from $P_{\perp}^2 = 0.3 \rightarrow 6.0$ and $P_{lab} \approx 40$ GeV/c
 then $\theta_{lab} = 1^\circ \rightarrow 4^\circ$ and one 2 meter steering magnet will be enough.



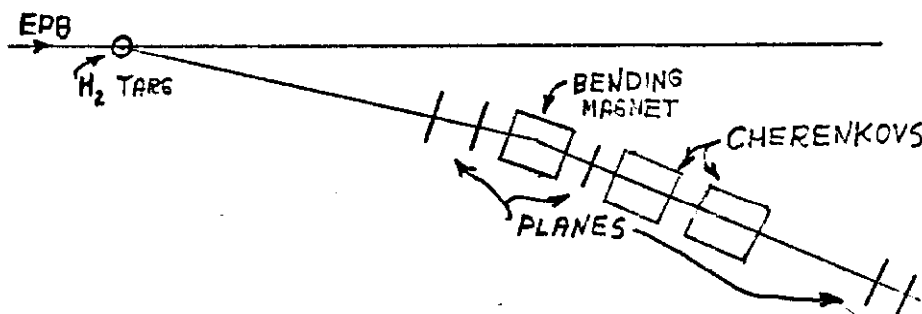
Again it will be necessary to have:

- a) Target station in EPB with room for steering magnet.
- b) Room for beam of ~ 1000 ft.

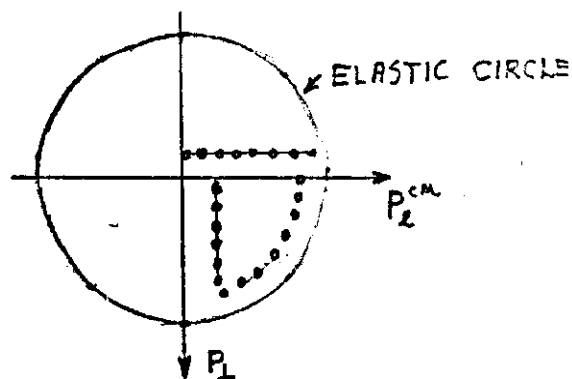
The study of $d^2\sigma/d\Omega dp$ is likely to be very interesting at 200 GeV. The
 two fireballs will probably move further apart and will be more easily
 studied.

INELASTIC PROTON SCATTERING $P+P \rightarrow P + \text{ANYTHING}$

In this experiment you detect only one proton in an inelastic pp
 collision. The experiment again consists of a single arm spectrometer
 either similar to the one for meson production or with planes of spark
 chambers (wire or conventional) or hodoscopes as shown.



You cover some range of P_{\perp} and P_{\perp}^{cm} for the proton taking care to stay away from the elastic proton circle. This experiment might be done in either the EPB itself if small cross sections are desired or in a diffraction scattered beam $\sim 10^7$ /pulse. If done in EPB probably will have to put a magnet and shielding in front of first plane if planes rather than scintillators are used. For 150 GeV protons $\gamma_0 = 1 - \beta \approx 5 \times 10^{-5}$ so that fairly good Cherenkov counters will be necessary to tag the protons.



This experiment is likely to be very interesting and will show what happens to the protons that interact inelastically.

ANGULAR DEPENDENCE OF ISOBAR PRODUCTION $P+P \rightarrow P + \text{MISSING MASS}$

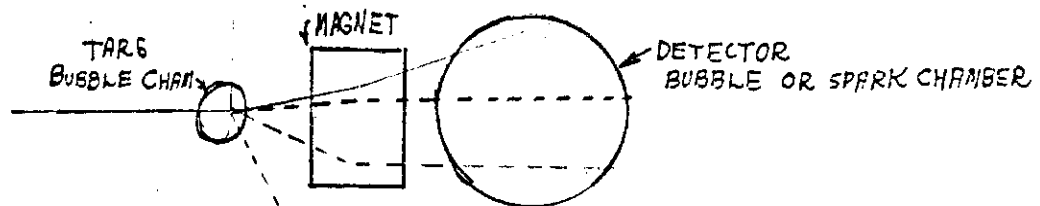
The setup for this experiment will be quite similar to the inelastic proton scattering experiment. However, here the emphasis will be on inelastic interactions in which the missing mass corresponds to a nucleon isobar. One will study the t or P_{\perp}^2 dependence of $P + P \rightarrow P + N^*$ for the various isobars. The principal problem will be obtaining good enough momentum resolution to uniquely identify the isobars. If this can be solved the experiment will probably be interesting.

STUDY OF "JETS"

In this experiment we study the process $p + p \rightarrow x_1 + \dots + x_n + x_{n+1} + \dots + x_m$ and you detect the first n particles. Then you measure a cross section of the type

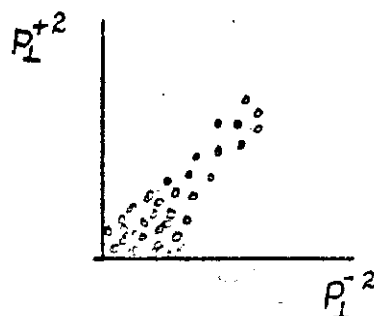
$$\frac{d^{2n}\sigma}{d\Omega_1 \dots d\Omega_n dP_1 \dots dP_n}$$

To obtain any reasonable rates you need a solid angle which is almost 4π in the cm and thus rather large in the lab. To obtain a large solid angle you need very large detectors semi-surrounding the target. This is impossible with a very high intensity EPB and the experiment should be done in a diffraction scattered proton beam of $\sim 10^6$ /pulse. One could use magnetic spark chambers or Bubble chambers. An idea is to use two B. C. 's with no magnetic field separated by a large magnet.



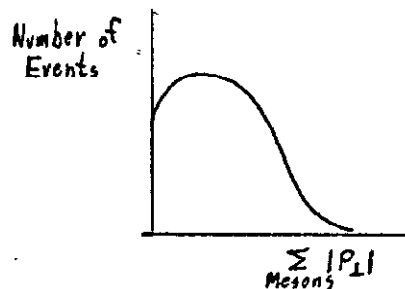
The major problem in this experiment will be presenting the data in some coherent way. Several ways of parameterizing data are presented below.

- a) Two body correlations: Take all $\pi^+ \pi^-$ pairs and plot things against the P_L^2 for each particle.

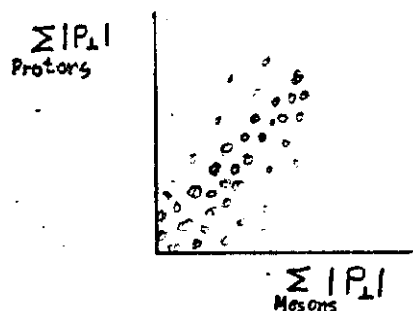


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- b) Plot the number of events against the total transverse momentum of all the produced meson. $\sum_{\text{mesons}} |P_{\perp}|$

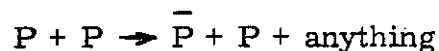
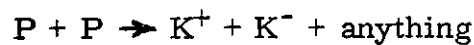


- c) Plot $\sum_{\text{mesons}} |P_{\perp}|$ against the sum of $|P_{\perp}|$ for the two protons in the process $P + P \rightarrow P + P + \text{mesons}$



CORRELATION EXPERIMENTS

Study the cross sections for processes like



This is a cross section of the type

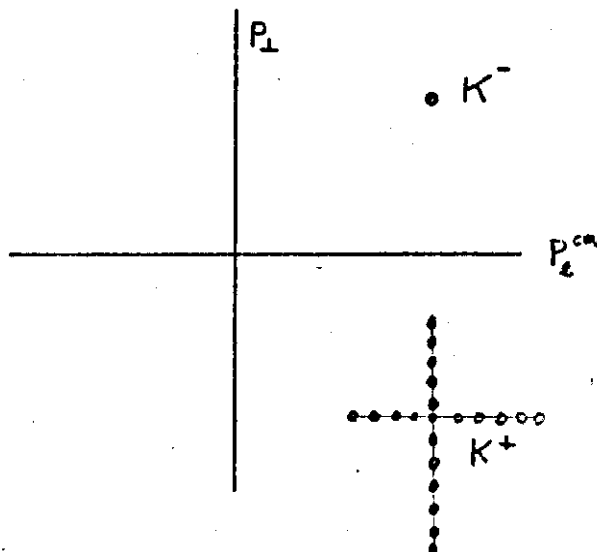
$$\frac{d^4\sigma}{d\Omega^+ d\Omega^- dP^+ dP^-}$$

It can be measured on an EPB with two spectrometers of the type used in the meson production experiment. The rates will be quite low since

$$\text{Events/pulse} = I_0 (N_{\text{opt}}) \frac{d^4\sigma}{d\Omega^+ dP^+ d\Omega^- dP^-} (\Delta\Omega \Delta p)^+ (\Delta\Omega \Delta p)^-$$

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and each $\Delta\Omega\Delta P \approx 10^{-5}$ GeV/c sr. It will be necessary to have high intensity $I_0 = 10^{11} \rightarrow 10^{12}$ /pulse. The experiment will consist of holding fixed the momentum of the K^- and varying the momentum of the K^+ . This could yield some very interesting results in correlation between the K^+ and K^- .



NEUTRON EXPERIMENTS

n-p elastic scattering

n-p total cross section for (p-d) minus (p-p) present technique
should work fairly well.

ENERGY DEPENDENCE OF A SINGLE CHANNEL

Measure the dependence of σ_{TOT} on incident energy for a single channel process such as charge exchange



See how fast it goes to zero. This will be interesting to see how much unitarity drives it.

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BACKWARD π^- P SCATTERING

Probably can measure $\pi^- p \rightarrow \pi^- p$ at 180° up to about 40 GeV with present techniques. Will be interesting in that you can look for massive nucleon isobars or if none exist, you can study the long range energy dependence

$\pi^\pm K^\pm P^-$ ELASTIC SCATTERING

Can be done with present techniques except will need large area because detection arms may be several hundred feet long. It will be necessary to tag particles. Because of low intensities $I_0 \approx 10^5 \rightarrow 10^8$ /pulse you probably cannot go past $P_\perp^2 = 3 \rightarrow 4 \text{ (GeV/c)}^2$ and are not likely to find anything very exciting. Nevertheless they should be done, especially K^\pm and \bar{P} where you can now only go to about $P_\perp^2 \approx 1.5 \text{ (GeV/c)}^2$.

K^0 EXPERIMENTS

Can be done here but are basically low energy experiments that can be done on other machines.

HYPERON BEAMS

Could be used for Λ -P and Σ^\pm -P total and elastic cross sections. However to avoid decay will need simultaneously high momentum and large angle production or large bends to get beam out fast. Very interesting but difficult.

HIGH ENERGY γ , e^\pm and μ^\pm BEAMS

Probably can go up to 60 GeV. They, however, will not be very competitive with SLAC especially if SLAC goes to 40 GeV.

POLARIZATION EXPERIMENTS

Although it is likely that spin effects will decrease with high energy, it is not certain. Probably some steps should be taken to build a polarized target or arrange with another laboratory to acquire theirs.

$\bar{P} + P \rightarrow \text{HYPERON} + \text{ANTIHYPERON}$

This experiment will be interesting and may have a reasonable cross section. At high energy there are more intense \bar{P} beams and the hyperons live longer.

ENERGY DEPENDENCE OF MULTIPLICITY

Measure the multiplicity of charged mesons or charged particles with good statistics at many points from 10 \rightarrow 200 GeV. This will give information about the nature of particle production.

ENERGY DEPENDENCE OF ELASTICITY

Look at the process $p + p \rightarrow p + p + \text{anything}$. Measure the cm. energy of the two final protons.. Plot the ratio $E_{pp}^{\text{final}} / E_{pp}^{\text{initial}}$ against incident energy for many incident energies from 10 \rightarrow 200 GeV. This will also give information about the nature of particle production.

RADIOCHEMISTRY

It is vital to measure some cross sections of protons on gold and aluminum at energies up to 200 GeV. Otherwise many of the experiments cannot be done. Probably a radiochemistry group should be started.